Cyprus University of Technology

THE IMPORTANCE OF A CARBON TAX ON TIMELY AND COST-EFFECTIVE DECARBONIZATION – A CASE STUDY FROM CYPRUS

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Climate Change

Strengthening the global response to the threat of climate change

Paris Agreement - “holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change”.

→ Highlights the necessity to peak global greenhouse gas (GHG) emissions.

Energy and Climate Targets

Increasingly stringent energy- and climate-related targets for the medium and long term.

Commitments: usually expressed as a pledge to curb GHG emissions by a certain percentage rate up to 2030, or 2050, compared to a reference year of the past.

Need to design proper and cost-effective decarbonization strategies.

The **EU's approach** is to **treat decarbonisation targets separately** for heavy industry and the rest of the economy.

ETS

- Heavy industrial installations (including power generation) are subject to the EU Emissions Trading System (ETS).

✓ The ETS is an EU-wide cap-and-trade scheme, in which national governments have specific tasks.

NON – ETS

- All other sectors of the economy (light industry, transport, agriculture, residential and commercial sectors) are subject to an aggregate emission reduction objective.

✓ National policy makers have the exclusive responsibility for implementing abatement measures in non-ETS sectors.

The research focuses on policies targeting non-ETS emissions

Related Work

→DEVELOPMENT OF A MARGINAL ABATEMENT COST (MAC) CURVE

- Bottom-up 'measure-explicit' MAC curve for the Republic of Cyprus, public policy perspective
- Identification of a country-specific cost-effective policy mix for 2030
- Diverse set of alternative calculations

→DEVELOPMENT OF A OPTIMIZATION MODEL

- Multi-constraint optimization model
- Examination of least-cost greenhouse gas emission abatement pathways
- Medium- and long-term targets
- Relationship between 2030 abatement targets of varying ambition and the possibility of achieving a strong

Aim of the Study

'Deep decarbonisation in the country's non-ETS sectors is very demanding'

Adoption of cost-effective greenhouse gas reduction measures coupled with the implementation of a gradually increasing carbon tax in these sectors.

We combine:

- Long-term energy forecast model that is used for national energy planning
- Multi-constrained optimization model that is used to identify the optimal timing and mix

Multi-constrained optimization model

Examine the **least-cost** greenhouse gas emission abatement **pathways**, taking into account:

a) emission reduction objectives for two years: 2030 and 2050;
b) variable abatement cost and potential of each measure;
c) variable potential speed of implementation of each measure, and
d) environmental side-benefits of these measures expressed in monetary terms.

Methodology

Set of options described by:

- their emissions **abatement cost**
- their emissions **abatement potential**, and
- their emissions **speed of implementation**

The optimization problem to be solved is the selection of the amount of abatement to be implemented by measure each year, in order to achieve future emission reduction targets at the minimum cost.

Objective function: the total present cost of abatement, *TC*
Decision variables: the abatement potential of each measure, *a*

Methodology | Mathematical Formulation

Objective function

$$TC = \sum_j \sum_t \frac{TC_{j,t}}{(1+r)^t} \qquad (1)$$

There are *N* abatement options, indexed by *j*.
The model runs for the period 2021-2050 with a time step of one year, *t*.

For each measure j:

$$TC_{j,t} = AC_{j,t} \cdot \sum_i \frac{a_{j,t}}{(1+r)^i} \qquad (2)$$

Abatement cost, *AC* and attainable **abatement potential,** *a*.

Methodology | Mathematical Formulation

Constraints (1)

For each measure there is a **maximum abatement potential,** *A*. The cumulative abatement of each measure up to 2050 cannot exceed the full abatement potential:

$$\sum_t a_{j,t} \leq A_j \qquad (3)$$

The **speed of implementation,** *s* express the maximum annual abatement that can be achieved.

$$a_{j,t} \leq s_{j,t} \qquad (4)$$

Speed of implementation can change over time, to reflect inertia in the uptake of low-carbon technologies and in consumer behaviour.

Methodology | Mathematical Formulation

Constraints (2)

Annual values of the **speed of implementation** s, depend on the cumulative amount of abatement that has already been deployed up to that year:

$$s_{j,t} = f\left(\sum_{i=1}^{t} a_{j,t}\right) \qquad (5)$$

The **emissions objectives** for given points in time *m* (2030 and 2050) that need to be satisfied, are set with the following emission constraint:

$$\sum_j \sum_{t=1}^{m} a_{j,t} \geq a_m^{objective} \qquad (6)$$

Simulation

We perform four different scenarios:

► Scenario I:

No additional measures
+ purchase of permits to cover 2030 emissions gap

► Scenario II:

Measures up to €30/tonne
+ purchase of permits to cover 2030 emissions gap

Unambitious Scenario

► Scenario III:

Measures up to €120/tonne
+ Carbon tax up to €120/tonne
+ purchase of permits to cover 2030 emissions gap

Ambitious Scenario

► Scenario IV:

All available measures
+ Carbon tax up to level to meet 2030 target

Results for all Scenarios up to 2030

Scenario	Investment costs (1000 €)	2030 emissions gap (ktCO2e)	Purchase of permits to cover 2030 emissions gap (1000 €)	Total Costs (1000 €)	Total Costs including the savings over the lifetime of measures (1000 €)	Total Costs including the savings over the lifetime of measures and externalities (1000 €)	2050 emissions gap (ktCO2e)
No additional measures + purchase of permits to cover 2030 emissions gap	€ -	1016.96	€ 128,113.31	€ 128,113.31	€ 128,113.31	€ 128,113.31	2978.60
Measures up to €30/tonne + purchase of permits to cover 2030 emissions gap	€ 105,214.41	955.1	Unambitious Scenario	21	-€ 216,444.45	-€ 257,363.25	1884.14
Measures up to €120/tonne + Carbon tax up to €120/tonne + purchase of permits to cover 2030 emissions gap	€ 1,573,837.37	431.3	Ambitious Scenario	.19	-€ 446,770.41	-€ 926,483.19	238.60
All available measures + Carbon tax up to level to meet 2030 target	€ 1,752,838.43	0.00	€ -	€ 1,752,838.43	-€ 924,161.20	-€ 1,407,308.45	0.00

Cumulative Emissions Abatement (% of the total abatement in 2050)

Unambitious Scenario: Measures up to €30/tonne
+ purchase of permits to cover 2030 emissions gap

Ambitious Scenario: Measures up to €120/tonne
+ Carbon tax up to €120/tonne
+ purchase of permits to cover 2030 emissions gap

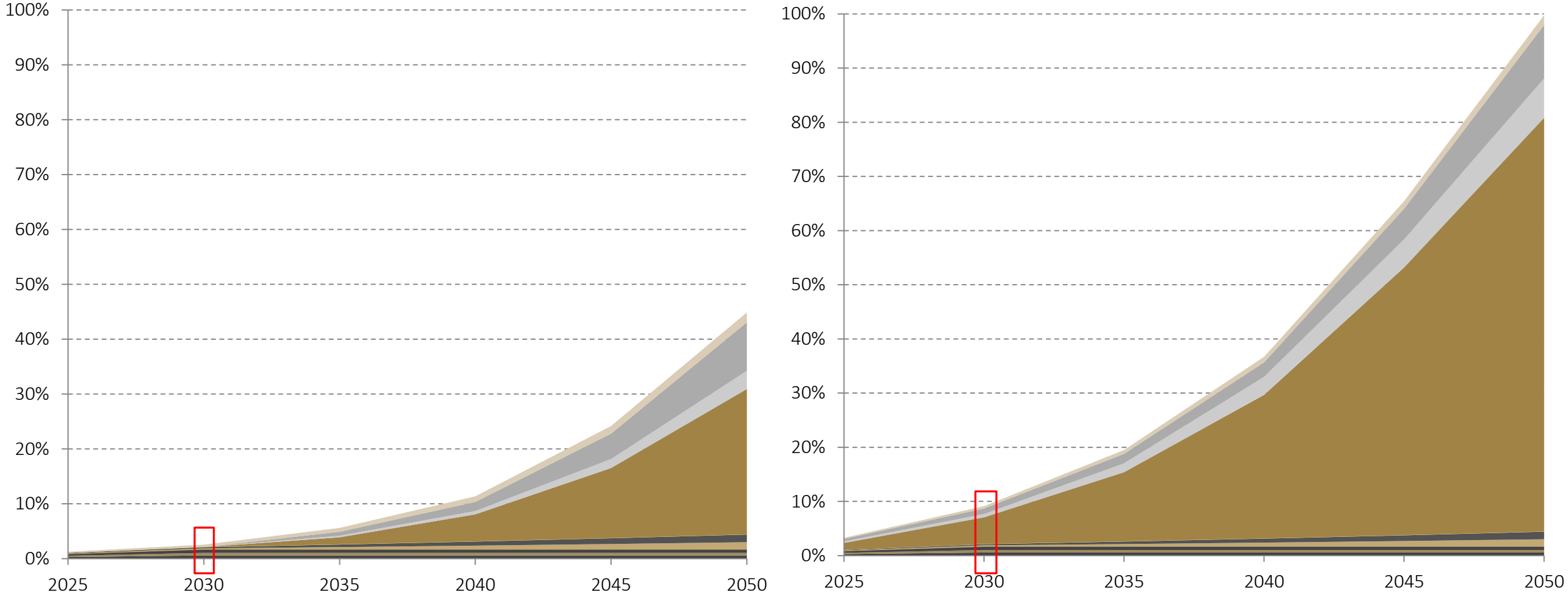

Figure 1: Emission abatement in non-ETS sectors up to 2050 by type of measure

Cumulative Emissions Abatement up to 2030 (% of the total abatement in 2050)

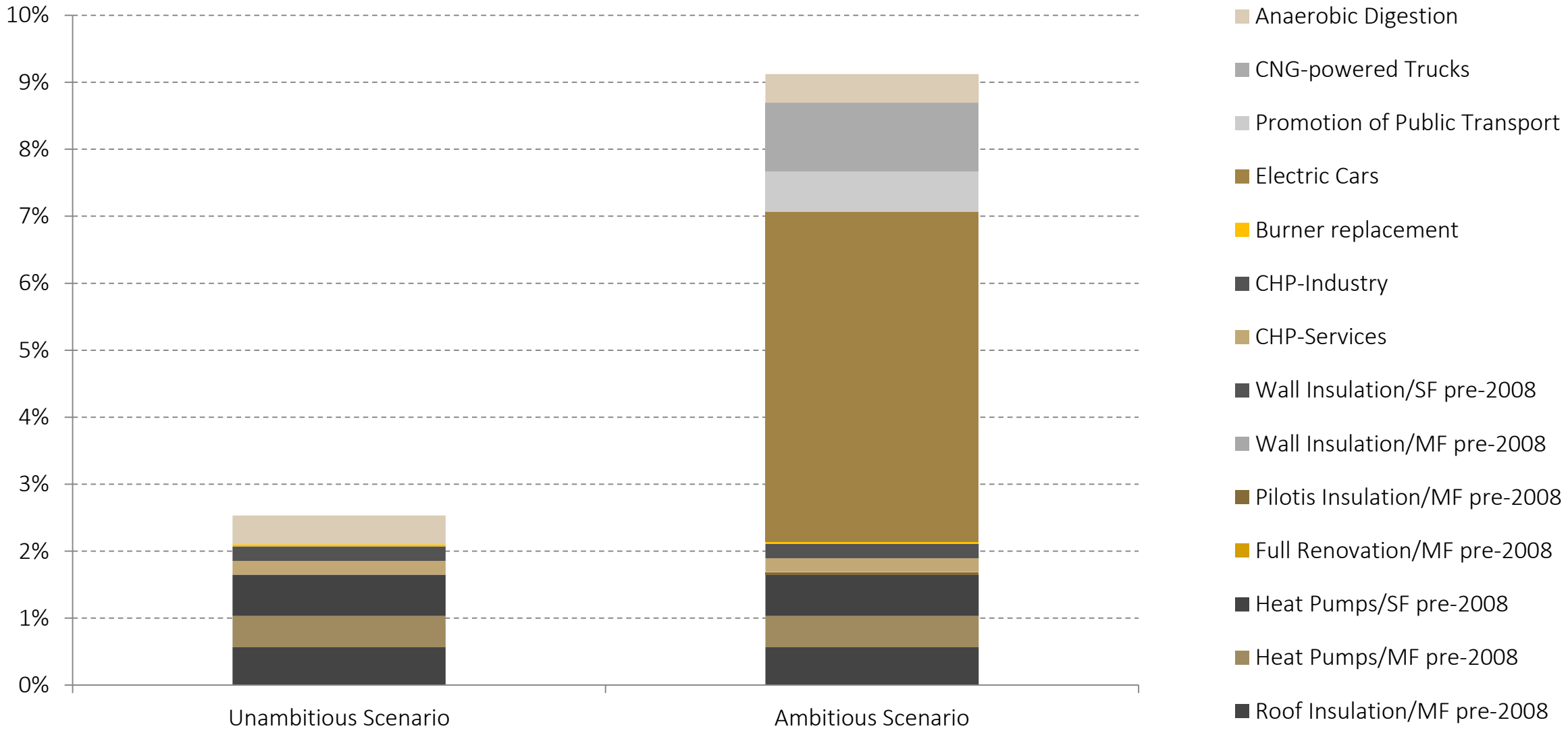

Figure 2: : Emission abatement in non-ETS sectors for the year 2030 by type of measure

Results for Scenarios III & IV up to 2050

Scenario	Investment costs (1000 €)	2030 emissions gap (ktCO2e)	Purchase of permits to cover 2030 emissions gap (1000 €)	Total Costs (1000 €)	Total Costs including the savings over the lifetime of measures (1000 €)	Total Costs including the savings over the lifetime of measures and externalities (1000 €)	2050 emissions gap (ktCO2e)
Measures up to €120/tonne + Carbon tax up to €120/tonne + purchase of permits to cover 2030 emissions gap	€ 8,134,178.80	431.37	€ 54,342.82	€ 8,188,521.62	-€ 841,931.25	-€ 2,980,964.46	238.60
All available measures + Carbon tax up to level to meet 2030 target	€ 7,458,832.42	0.00	€ -	€ 7,458,832.42	-€ 2,981,642.03	-€ 5,023,943.92	0.00

Wrap up

- Deep decarbonization in the country's non-ETS sectors is very demanding;
- The implementation of all mitigation measures identified in non-ETS sectors is not sufficient to fulfil the country's medium- and long-term climate targets;
- Adoption of cost-effective greenhouse gas reduction measures coupled with the implementation of a gradually increasing carbon tax in these sectors is necessary;
- Quantity of short-term abatement must be aligned with long-term decarbonisation;
- Unambitious medium-term scenarios could miss key and essential economic sectors for achieving deep decarbonization (quality of abatement);
- 'lock-in' effect - prioritizing abatement options which are cheaper and faster to implement but do not have sufficient potential to meet ambitious abatement targets must be avoided;
- Early deployment: Implementation of seemingly expensive measures is necessary in order to achieve serious decarbonization in 2050;

Thank you!

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